News Round-up

More Money for Colonial Development in 1960

Grants and loans approved under the Colonial Development and Welfare Act in 1960 amounted to well over £40 million or almost £13 million more than in 1959.

Money made available for schemes to benefit Colonial territories included some £10 million for education, £7¾ million for road developments, £4 million for agricultural and veterinary services, £2¾ million for medical and health services, almost £3 million for research, £2½ million for industrial developments and £1½ million for water supplies and sanitation.

Tyre Factory for Nigeria

The Michelin Tyre Co. Ltd. in the United Kingdom has reached an agreement with the Government of the Eastern Region of Nigeria for the establishment of a tyre factory. At present there is no tyre factory in Nigeria. The new British/Nigerian project will, therefore, meet the needs of this important market. A company spokesman said recently, 'It is expected that some 400 Nigerians will be employed in management, skilled and semi-skilled positions. Initially, technicians from the parent company will advise on technical and production processes.' Work is expected to start on the erection of the new factory next October-November, immediately after the rainy season.

More Uganda Africans as District Medical Officers

Of the 15 Districts in Uganda, nine are now in the medical charge of African District Medical Officers. A recent appointment is that of Dr. P. S. B. Muganwa, who was transferred in December, 1960, from the Headquarters at Entebbe to take over Lango District.

Aerial Survey of Uganda to aid Mineral Exploration

An aerial geophysical survey is to be carried out in Uganda with the United Nations' help, with the object of assisting mineral exploration. The cost of the survey will be shared between the Uganda Protectorate and the U.N. Special Funds. After the aerial survey is completed the Protectorate government will follow up with a ground survey.

U.K. Technical Assistance Office in Trinidad

The United Nations' Technical Assistance Board has opened a regional office in Trinidad, federal capital of the West Indies. It is under the direction of Mr. James Keen, U.N. representative in the Caribbean area.

The Trinidad office is the latest of some 40 offices which have been set up throughout the world to administer the United Nations' programmes for technical co-operation.

High Quality of Kenya Geranium Oil

The Reunion type of geranium oil now being produced in Kenya reaches the highest standards. Samples of geranium oil received recently from Kenya by the Tropical Products Institute have been very well received by the cosmetics trade and there seems no reason why this should not become a standard Kenya oil. The crop should prove a worthwhile proposition for both African and European growers in Kenya as it is one of the most paying crops for those unable to grow coffee. The Highlands of Kenya are eminently suitable for geranium plants. Trade circles are interested only in supplies closely resembling the Reunion variety of geranium.

Rise in Fruit Imports to the United Kingdom

Imports of fruit to the U.K. in 1960 showed an increase of 4 per cent. over the previous year. This increase was mainly in oranges, grapefruit, bananas, grapes and melons, while there was a slight decrease in apples, plums and lemons. Of the total fresh fruit imports, 54 per cent. came from Commonwealth countries, there being increases in supplies from Kenya, Jamaica and the British Cameroons.

Agricultural Machinery and Soil Conservation Training Centre for Iran

The British Government and the other members of the Central Treaty Organisation—Iran, Turkey and Pakistan—have approved plans for the opening in 1962 of an agricultural machinery and soil conservation training centre in Iran. Much advice and assistance has been obtained from organisations and the agricultural engineering industry in Britain and the four countries will share the cost. Training will be provided for 25 students at a time.

British Council Courses for Overseas Specialists

More than 250 overseas specialists on subjects varying from archaeology to town planning will be welcomed to Britain by the British Council this year. They are to take part in a series of specialist courses arranged every year by the Council. This year there are 16 courses under the headings of agriculture and veterinary science, arts and humanities, engineering, finance, medicine and sociology.

Meat Cannery for Bechuanaland

The Colonial Development Corporation has arranged, through its subsidiary company, Bechuanaland Protectorate Abattoirs Ltd., to establish a meat cannery in conjunction with the abattoir at Lobatsi in Bechuanaland. The new company will be named Export and Cannery Company Ltd.

Smallholder Tea-growing in Kenya

An agreement has been reached between the Kenya Government and the Colonial Development Corporation to promote the growing of tea by African smallholders in the Central, Nyanza and Rift Valley Provinces of Kenya. Plans envisage the development of 9,000 acres of smallholder tea, involving the provision of finance estimated at £960,000 over eight years. C.D.C. has undertaken to lend £900,000 and the Kenya Government will lend £60,000, in addition to financing expenditure on the necessary access roads and staff housing.

A new statutory body, called the Special Crops Development Authority, has been set up to control and supervise the development. The Board of the Authority consists of representatives of the Government, C.D.C. and the growers. The scheme is designed to pay for itself on a completely economic basis. If the initial programme is successful, there is likely to be considerable expansion beyond the limits now planned.

Britain Increases Aid to South and South-East Asia

Britain continues to be the largest contributor after the United States to the Colombo Plan system of aid to developing countries in South and South-East Asia.

Last year its rate of capital expenditure for development purposes was the highest since the plan was launched in 1951, totalling £44½ million compared with about £30 million the previous year and an average of £13 million in earlier years.

These facts are contained in the Ninth Annual Report of the Colombo Plan Consultative Committee.* The report draws a picture of new industries being established, large numbers of people being trained, modern techniques adopted

* 'Colombo Plan for Co-operative Economic Development in South and South-East Asia'. H.M.S.O. 9*s*. 6*d*.

in agriculture, irrigation projects bringing water to parched fields, additional power granted for industry, illiteracy being reduced and malaria eradicated; but much remains to be done. The decision to extend the plan until 1966 is a recognition of the urgency of the remaining problems and of the importance of effective international co-operation to meet them.

World Bank Mission Urges Investment in Uganda's Agriculture

The opening up of virgin land in Uganda and general agricultural expansion are foreshadowed in the findings of a World Bank mission which has been making detailed studies of economic potentialities in the Protectorate.

The members of the mission, led by Professor Edward S. Mason, are at present sifting evidence and writing their full report. They expect to submit the report to the Uganda Government about next July.

Following an application by the Uganda Government for a loan to develop feeder roads through the Protectorate, a second World Bank Project Mission spent three weeks making on-the-spot examinations in the areas concerned.

The project aims at opening up fresh parts of fertile country for settlement and cultivation by people from over-populated areas and at facilitating the movement of cash crops and consumer goods.

International Seed Year

Overseas students and workers concerned with problems of increasing food production in their own countries will be able to 'tap' the fund of knowledge in Britain when they attend a special course at Cambridge later this year.

Specialists in seed testing multiplication and certification will teach them the latest techniques to enable them to introduce similar procedures into their own countries and so bring about increases in food production.

The course takes place in June and July at the National Institute of Agricultural Botany, Cambridge. It is part of the U.K. effort for International Seed Year, as 1961 has been designated by the Food and Agricultural Organisation of the United Nations in its international campaign to boost world food production.

Bilharzia:
The New Importance of an Old Disease

By R. Muller

Colonial Pesticides Research Committee

Summary

An account is given of the distribution and pathology of the tropical disease, bilharzia. The life cycle of the causative agent, a parasitic fluke, is described, and the main lines of attack that this suggests are outlined. It is concluded that the disease is liable to spread with the growth of irrigation schemes in underdeveloped countries.

Introduction

Bilharzia is almost unknown in temperate climates, even by repute, not having the spectacular impact of malaria and sleeping sickness. However it is widespread in many tropical countries and, in areas where the disease occurs, a large proportion of the population is infected.

It is a debilitating ailment and can cause chronic ill-health extending over many years. The disease occurs in varying degrees of severity, sometimes being practically symptomless, with perhaps mild dysentery or bloody urine, but it can be the cause of severe damage to the bladder or intestine, and to other organs such as the liver, leading to incapacity and death. The disease is spread by certain types of water snails carrying the larval stages of the worms causing the infection. These burrow their way out from the snails and penetrate the skin of human beings.

Although not usually a severe disease, there is a very real danger of its spreading with the extension and introduction of new irrigation schemes, which are playing an increasingly important part in the further development of underdeveloped countries. Indeed, an increase in the number of persons infected due to this cause has already occurred in an area of the Congo and in the Eastern Transvaal. A rise in the infection rate from 2 to 75 per cent. of the population was noted in the three years 1934-37 in Binban, in the Aswan district of Egypt, after the introduction of a perennial irrigation scheme and the disease is likely to spread considerably when the Aswan High Dam is built. The propagation of the disease has also been associated with irrigation schemes in Iraq, Algeria, China, and Japan. In Southern Rhodesia the Unshandige irrigation scheme was abandoned in 1949 after 10 years, at a cost of £3 million, because of the frightening increase in bilharzia and malaria.

This disease is the most ancient that is known, with complete certainty, to have attacked man, the eggs of the parasite having been found in the kidneys of Egyptian mummies of the twentieth dynasty (1250-1000 B.C.).

Clinical accounts of a disease closely resembling bilharzia have been found in papyri; one from about 1500 B.C. gives a remedy for killing worms, which are formed in the body by the AAA disease (this was probably bilharzia). Numerous mentions of its symptoms have been found in Babylonian inscriptions and in medieval literature. In more recent times it was observed in the French army of occupation in Egypt from 1799 to 1801. The first demonstration of the causative agent was made by Theodor Bilharz in 1851 in the mesenteric veins of an Egyptian in Cairo and he later showed the relationship of the parasite to the haematuria (blood in the urine) and dysentery so prevalent in Egypt, concomitant with the growth of the irrigation systems in the nineteenth century. It is probable that the disease was introduced to the New World from Africa, infected snails being transported in the water barrels of slave ships. The life cycle and mode of transmission were elucidated in the present century.

It has recently been estimated that at least 150 million people have this disease at the present time, although a full survey of its extent has never been made. Estimates of the incidence in some countries made by different experts are as follows:[1]

Egypt	12	million	people	infected
West and Central Africa	9	,,	,,	,,
Brazil	4	,,	,,	,,
China	32	,,	,,	,,
Philippines	¼	,,	,,	,,

It is probable that these figures are much too low, because repeated examination is sometimes necessary before a positive diagnosis is obtained.

Although man is the principal definitive host other hosts are encountered in nature. The presence of an animal reservoir for a human disease is known as a zoonosis, and is of the greatest importance in the epidemiology of many tropical diseases, such as sleeping sickness, yellow fever and rabies. So far as bilharzia is concerned, animal hosts have not been shown to be important in the spread or continuation of the disease in Africa or America but may be so for Oriental bilharziasis. On Leyte Island in the Philippines, 275 of the 1,517 dogs on the island are infected with the worm, 29 of the 76 cows, and also a number of pigs, rats, carabao (water buffalo) and goats.[2] Man transmits the disease at a very much higher rate than, for example, dogs, 48 per cent. of the human population being infected. Sixty per cent. of the total infection comes from children aged 10-14 years, the age group which also provides most of the victims. Thus the first essential is for medical care and public health measures directed principally at this age group. However, a careful check will have to be kept on the dog and cow populations in the endemic areas. The importance of animal reservoirs in Africa and America should not be underestimated, particularly after the example provided by yellow fever which, it was thought, was virtually eradicated from Central America until the presence of 'jungle yellow fever' in monkeys was demonstrated. In Africa, monkeys are natural hosts of human bilharzia and in certain areas of the Congo 5 per cent. of wild rodents are infected. Naturally

infected small mammals have also been found in Brazil. Such reservoirs of infection may be of greater importance when methods of control are considerably more advanced.

Geographical Distribution

The disease in man is widespread in the tropics (Fig. 1) and is due to one of three species of flatworms, termed schistosomes. It has differing symptoms, depending on their location in the host.

Urinary bilharziasis

Schistosoma haematobium is the cause of the urinary form of the disease and is confined to Africa and the Middle East. In West and Central Africa it is widespread in the north of Nigeria and Ghana, and is prevalent in Gambia, Liberia, Sierra Leone, Togo, and the Cameroons. In East Africa the disease is common in Uganda, Tanganyika, Zanzibar, Nyasaland, Mozambique, Swaziland, and Madagascar. Widespread infection occurs in both Northern and Southern Rhodesia and is also found in parts of Mauritius and the Union of South Africa. In North Africa it is highly endemic in the valley of the Nile and foci exist along the Mediterranean coast as far as Morocco, and extend eastwards to Israel, Syria, Iraq and Yemen. Foci of infection also occur in Portugal, Greece and Cyprus.

Manson's bilharziasis

Schistosoma mansoni causes a mainly intestinal form of the disease and is present in Africa, the Middle East, and in South America and the West Indies. In Africa this form is often found in association with the previous one and the distribution of the two species is somewhat confused. In the Middle East it is found in Saudi Arabia, the Yemen, and in Israel. In North Africa it occurs in Egypt, Libya and Sudan. In West Africa there are recognised foci in Liberia, Guinea, Northern Ghana and Nigeria, Togo and Dahomey. It is prevalent in the Congo and Uganda and is found in regions of Kenya, Tanganyika, Nyasaland, Mozambique, Swaziland, Madagascar, Union of South Africa, and is widespread in Northern and Southern Rhodesia. It is now prevalent in Brazil, the Guianas and Venezuela, and in the West Indies is found in Martinique, Guadeloupe, Antigua, Santa Lucia, the Dominican Republic and Puerto Rico. The disease has apparently died out recently in St. Kitts.

Oriental bilharziasis

Schistosoma japonicum: This is the causative agent of an intestinal form of the disease, similar to Manson's bilharziasis but usually more severe. It is confined to the Far East, endemic areas occurring in Japan, China (particularly along the Yellow River), Formosa, Celebes and the Philippines.

Pathogenicity

In most tropical countries there is a high prevalence of common helmintic ('worm') infections, such as roundworm (*Ascaris*), hookworm

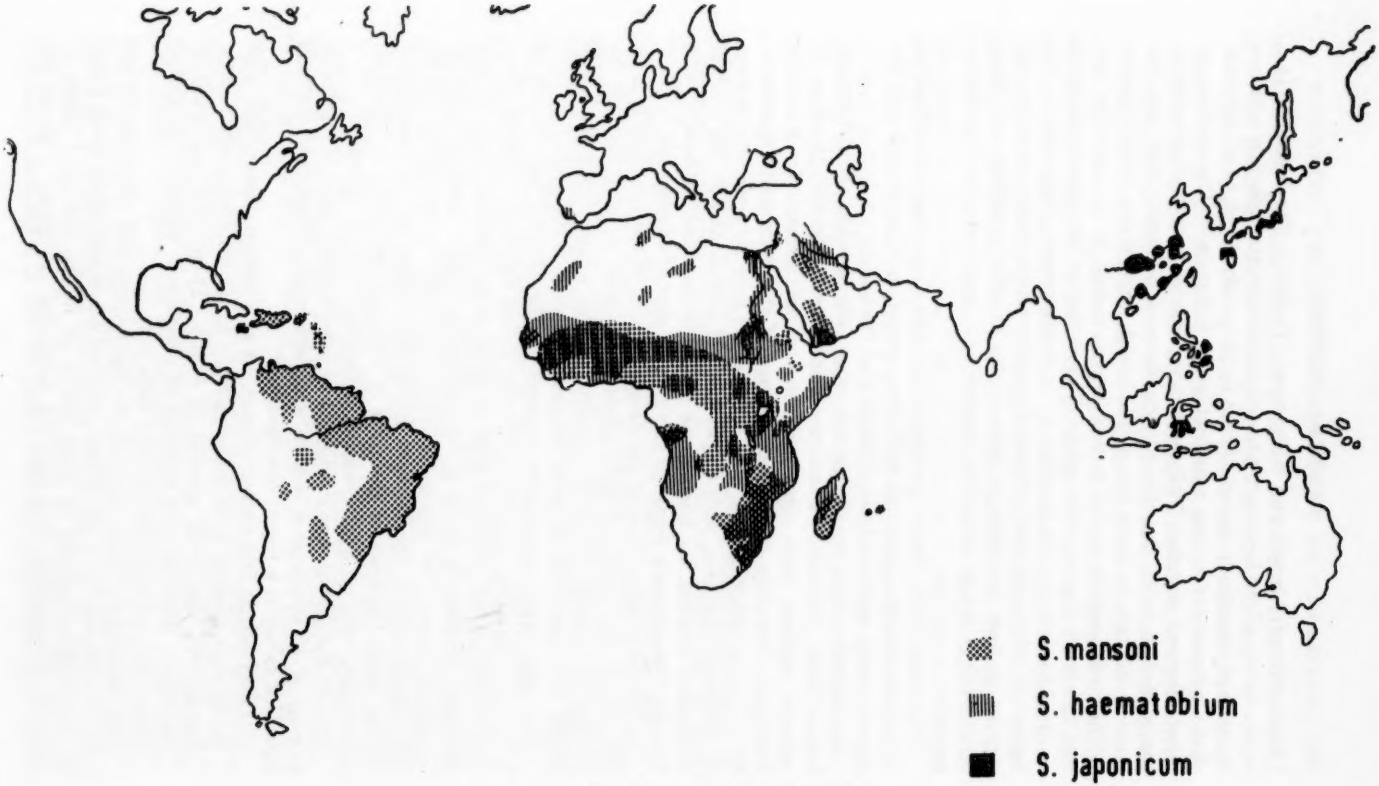

FIG. 1. World distribution of bilharzia

(*Ancylostoma* or *Necator*) and whipworm (*Trichuris*). For instance, in a recent survey of the Leyte province of the Philippines, infection with one or more of these parasites was found to be present in 98 to 99 per cent. of the persons undergoing examination for bilharzia.[2] The presence of these infections, together with the almost universal presence of malaria, has tended to mask the clinical symptoms of bilharzia; and has thus made it difficult to assess the public health importance of this disease.

The pathogenicity is due to two causes, mainly to the extruded ova and, to a lesser degree, to the adults. The severity of the infection depends on its duration, on the number of parasites present, and also on the frequency of reinfection. However, post-mortem study leads to the conclusion that the damage done to the bladder, intestine and lungs far outweighs what would be expected on parasitological or clinical grounds.

The course of the disease can be divided into three stages: incubational stage; acute stage, associated with the production of many ova; and the chronic stage, with gradual thickening of tissues.

In the early stages an allergic reaction to the growing parasite occurs, causing fever, pulmonary involvement and liver congestion. However, in endemic regions these signs are rare or not noticed. In Rhodesia, Europeans complain of tiredness as one of the main early symptoms. With a light infection very little other effect may be apparent: indeed, in Southern Rhodesia, with 80 per cent. of natives and 10 per cent. of Europeans infected, the haematuria (blood in the urine) associated with Urinary bilharziasis is regarded as a normal part of adolescence.

In the later stages most of the damage is due to the ova, and it is for this reason that Oriental bilharziasis is the most serious, because the schistosomes produce a larger number of eggs which, being small and round, are more likely to reach unusual sites such as the brain.

The eggs cause progressive changes in the bladder and ureter in Urinary bilharziasis, sometimes affecting kidney function. It has not been proved conclusively that they lead to cancer of the bladder, but it is very probable, particularly as this is the commonest form of malignant tumour in endemic areas. The eggs of the other two species cause mainly hepatic and colonic lesions, the intestine finally resembling an old, non-elastic garden hose. Cirrhosis of the liver is common, especially in Oriental bilharziasis, with an accompanying enlargement of the spleen.

Because the disease is so mild in many cases and the onset of symptoms so gradual, its importance is often under-estimated. Honey and Gelfand have this to say in a recent monograph:[3]

> 'Many people still regard bilharziasis as a benign disease, not to be feared and causing little inconvenience apart from occasional slight haematuria, and mild general ill health. These ideas are hard to contradict, since the vast majority of people who contract the disease either have no symptoms or very mild ones.'

This attitude no doubt accounts for the general lack of interest in the public health aspects of the disease, infected snails sometimes being found in the public fountains of large towns or in the ablutions basins of mosques. If invariably true that the symptoms are slight, it would not

be worthwhile spending large sums of money on its eradication. However, in a later paragraph on the same page the above authors say:

> 'Our studies have shown that in a small but significant number of cases serious complications can arise years after the infestation, and one of the tragedies is that these complications affect comparatively young people. The majority of our patients who were suffering from the late results of this disease were under 25 years of age.'

It must also be borne in mind that this account refers to Urinary bilharziasis, which is the least serious form. The insidious nature of the disease in children can affect their physical and mental development, particularly when, as is so often the case, it is associated with other diseases. In adults, the work done is often adapted to the disease, so that the effects are not apparent until an extra effort is required, when the symptoms are exacerbated. This was apparent during the war when large public works schemes were undertaken.

It has been estimated that in infections of Oriental bilharziasis the working ability of patients is reduced by about 15 to 18 per cent. in mild cases, by 50 to 57 per cent. in moderate cases, and by 72 to 80 per cent. in severe cases.

Life Cycle

A knowledge of the life cycle (Fig. 2) of the worms causing the disease is a necessary preliminary to any study of the methods which can be used to cure it.

The adults of the species of schistosomes causing disease in man all live in the small branches (venules) of the mesenteric veins. *Schistosoma mansoni* and *S. japonicum* inhabit the veins of the mesenteric-portal system, and *S. haematobium* those of the pelvic region. This difference is reflected in the type of disease caused.

The adult worms are about one to two centimetres long and live paired together in the venules, the more slender females being enclosed in a ventral groove or 'canal' formed by the curve of the male's body (Plates I and II). They thus provide an example of monogamy of unusual permanence. The pairs may be very long-lived in the human, the female producing eggs continuously for 20 to 30 years. When ready to lay eggs, the female worm moves as far as she can towards the capillaries of the venule, then moves back, depositing eggs behind her like a string of beads. The eggs are deposited in the venules of the colon or rectum (*Schistosoma mansoni* or *S. japonicum*) or of the bladder (*S. haematobium*).

The enclosed larva secretes a cytolytic fluid that oozes through the pores of the egg shell and enables the egg to migrate through the walls of the blood vessels into the rectum or bladder, depending on the species. This process is also aided by the mechanical action of a spine which projects from the egg. The eggs of *S. japonicum* are always passed in the faeces, those of *S. mansoni* usually so but occasionally in the urine, while the eggs of *S. haematobium* are passed more often in the urine (up to 100,000 can be passed in a day). The egg must reach fresh water, a process which is aided in the Far East by the use of night soil as fertilizer

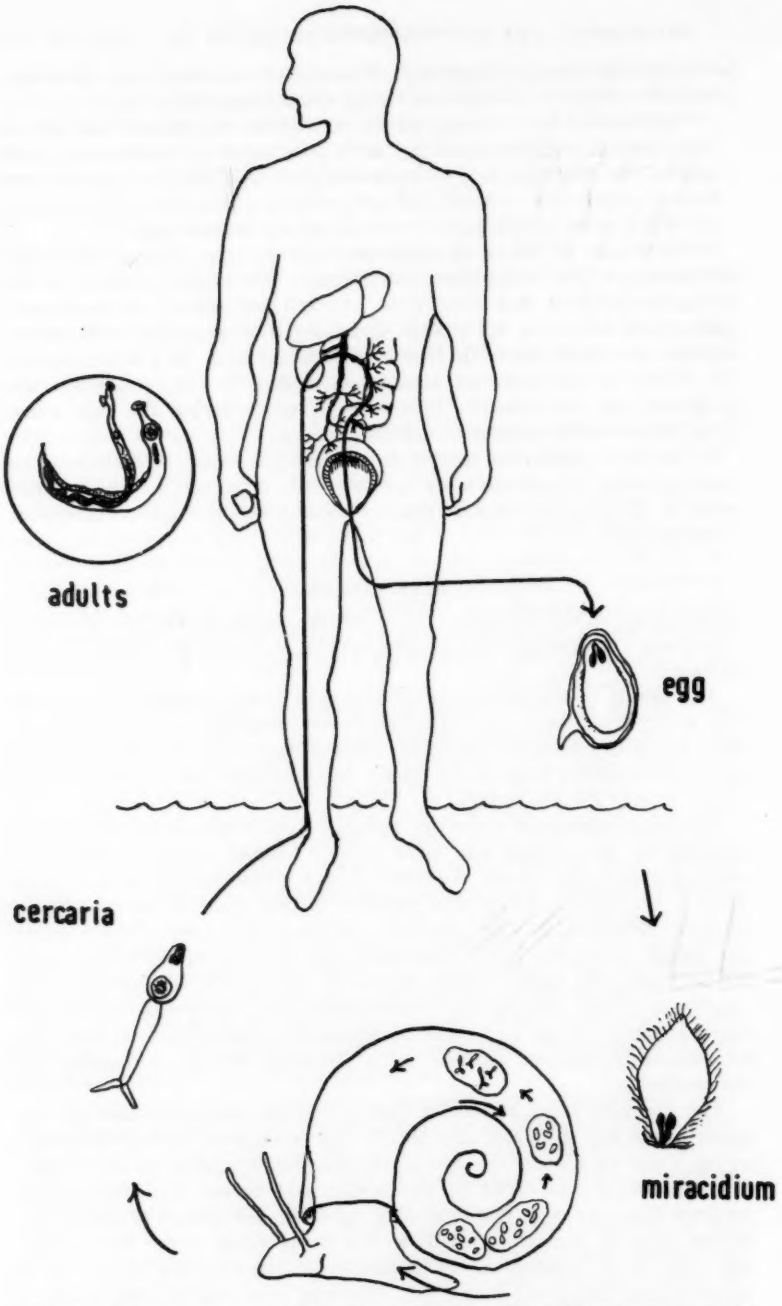

FIG. 2 Diagrammatic representation of the life cycle of *Schistosoma mansoni*

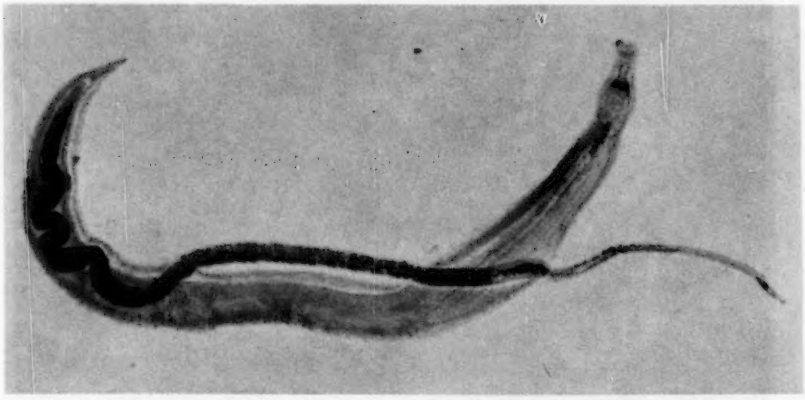

PLATE I. Adult worms of *Schistosoma mansoni*. The slimmer female is carried in a canal formed by the curve of the male's body. Stained specimen magnified about 15 times

PLATE II. Section across a small vein with interior completely blocked by four pairs of worms. Magnified about 75 times

[*facing page 12*

PLATE III. Snail host of bilharzia from South America (*Australorbis glabratus*). Numerous young snails and egg masses are on the leaves of the plant. Magnified three times

[*Courtesy: World Health Organization*

PLATE IV. Clinical case of bilharzia in Brazil, with enlargement of spleen

[*Courtesy: World Health Organization*

PLATE V. A bilharzia-infected stream in Brazil, in which women wash clothes and children paddle

[*Courtesy: Dr. Bloss, Wellcome Museum of Medical Science*

PLATE VI. Children fishing and bathing in an infected pool in the Sudan

[*Courtesy: World Health Organization*

PLATE VII. A farmer in Leyte Island, Philippines, ploughing. This is a typical habitat for the snails of Oriental bilharziasis

facing page 13]

on rice paddies. The egg hatches in from two to 16 hours, under optimum conditions, to give a minute, ciliated, free-swimming larva called a miracidium (Fig. 2).

The larva must find a snail of a suitable species within a very short time (16 to 32 hours). The snails are amphibious forms for the larvae of *S. japonicum*, but aquatic species for the other two schistosomes. The species of snail varies from place to place, but usually the larvae penetrate and develop further in only one or two out of the many types present. When the miracidium finds a suitable intermediate host, it penetrates the skin and undergoes a stage of enormous multiplication in the digestive gland. It forms into a hollow sac, termed a sporocyst and, by a process of asexual reproduction, becomes filled with daughter sporocysts. Each of these grows and in turn contains many embryos. These form the next free-living stage of the life cycle, normally burrowing their way through the skin of the snail after four to five weeks; but the period may be anything from two to 12 weeks, depending on the temperature of the water. This stage is a free-swimming, fork-tailed 'tadpole' about 0·2 millimetres long, termed a cercaria (Fig. 2). A large number of these cercaria are produced; the snail *Australorbis glabratus*, a vector in South America (Plate III), was found to liberate an average of 4,600 daily while the infection lasted, and some liberated a total of over half a million if the snail survived for four months.(4) One snail shed 17,600 cercariae in a single day and this number could be produced from a single miracidium. The most favourable temperatures for shedding were found to be between 19° and 37°C, the process being completely inhibited below 13° and above 41°C. The cercariae usually emerge from the snail during the day and can live for a maximum of three days, but often lose their infectivity after two. Agitation of the water by any mammal stimulates their activity, penetration of the skin of a suitable host occurring very quickly. A brisk rub down with a towel directly after exposure may, however, considerably reduce the number penetrating. The larvae can penetrate unbroken skin and are sometimes ingested in drinking water. Cercariae of the flukes of animals may also penetrate the skin but cannot develop further in human beings. In some waters they cause a very painful eruption known as swimmers itch.

Once in the final host, they migrate, *via* the lungs, to the liver and finally to the sites that they occupy as adults (Plate IV). Eggs can be recovered in a minimum of four weeks after infection.

Methods of Control

Three lines of attack are suggested by a study of the life cycle of the parasite:

1. *Improved Sanitary Habits*

This will provide the only complete method of control but is extremely difficult to carry out in practice, requiring the active support of the population. All the countries in which the disease occurs have a hot climate and the temptation to bathe in pools, streams and canals is great, particularly to children (Plates V and VI).

Progress in this line of attack is likely to be slow, dependent on a higher standard of living and involving a change in the habits and traditional customs of centuries.

In the East, where human faeces provide an important source of fertilizer, something can probably be done to store this away from water before use until the miracidia are dead.

2. *Mass Chemotherapy*

As well as acting as a method of control, chemotherapy is of primary importance in curing and relieving the symptoms of those infected. Unfortunately no completely satisfactory drug has been found. The earliest compound used was tartar emetic (potassium antimony tartrate) in 1917 and antimony compounds have continued to be important. However, they require a course of about 15 intravenous injections over a month, and cause many side-effects such as vomiting and sometimes total collapse. In the last few years a new antimony compound, sodium antimony alpha alpha'-dimercapto succinate (TWSb), which differs from antimony tartrate by having the oxygen atoms of the hydroxyl groups replaced by sulphur, has shown very promising results, with only mild side-effects.

A widely used compound, lucanthone hydrochloride (Miracil D), was discovered in Germany during the war, but was not given large-scale trials until afterwards. It has the great advantage of being taken by mouth. Clinical trials have been carried out in Africa, the Middle East, and South America. In Southern Rhodesia a review of results of trials[5] show that, out of 230 patients, 204 were cured at the end of a month. However, enteric or sugar-coated tablets were not so successful, only 80 out of 166 cases being cured. In a mass treatment of 2,605 patients, only 1,908 attended the full course. The poor attendance was largely due to the constipation and loss of appetite, which were experienced as side-effects. Some neurological manifestations have also been reported, patients complaining that doors and trees appear to be moving away as they walk towards them, until finally they collide with them.

3. *Attack on the Snail Vectors*

The schistosomes infecting man are very specific in regard to snail intermediate hosts and, if some means can be found of exterminating or reducing the numbers of vector snails to a level when transmission is unlikely, the life cycle of the parasite will be interrupted. In practice this line of attack provides the best short-term policy, particularly if it can be combined with a programme of effective prophylaxis.

(a) *Ecological methods of control.* These methods involve making the habitat unsuitable for snails by means such as alternate flooding and drying of water channels, covering and lining of canals, or piping of water. They are usually very expensive and require much greater co-operation between public health authorities and irrigation engineers in planning of irrigation schemes than exists at present. In some cases all that may be required is to deepen canals and clear weeds in order to increase the water flow. Watson [6] found that the habitat of *Bulinus truncatus*, the

vector snail of Urinary bilharziasis in Iraqi irrigation channels, consisted of pools of semi-stagnant water, usually polluted with human waste. The periodic drying of canals may not be fully effective however. Numerous investigators have noted the survival of snails in dried canals and also in seasonal ponds. Owing to the vast biological potential of the snails, one or two survivors can repopulate a habitat in a matter of months when conditions are again suitable.

In some cases the measures which destroy snails may also bring other benefits. On Leyte island, in the Philippines, agriculture is very primitive, no drainage of the rice paddies being carried out. The weeds are simply trampled into the mud by water buffalo (Plate VII). With improved methods of agriculture and dyking, the rice yield of a test area was doubled, while the numbers of amphibious snail vectors of Oriental bilharziasis were reduced by 90 per cent.[2]

As with the vectors of so many other tropical diseases, more studies on the ecology and biology of the snail are necessary before the most effective measures of control can be applied.

(b) *Biological methods of control.* Attempts to control populations of snails by the use of natural predators or parasites has been tried from time to time, but usually, under natural conditions, an equilibrium is set up. The use of water fowl, particularly ducks, has frequently been suggested. Molluscs only form a supplementary portion of their diet however and, even if the population of snails is slightly reduced, the dispersal of the young snails by the feet of the birds is probably of more importance.

In the last four years a large snail competitor, *Marisa cornuarietis*, has successfully displaced the vector snail in laboratory and field trials in Puerto Rico.[7] It has done this by being such a voracious feeder that it ingests the egg-masses of *Australorbis* on vegetation, and also destroys the newly-hatched snails, perhaps by feeding on them. However, these two snails live together in parts of South America without interfering with one another, and a biological equilibrium may eventually be reached in Puerto Rico.

A gram-variable bacterium (*Bacillus pinotti*) was isolated from the ovotestis of *Australorbis* by Diaz[8], which developed virulence after repeated serial passage through the snail host. It gave successful laboratory and field trials in Brazil and hopeful ones in Egypt, but later trials have not confirmed its success. (Watson, 1960, personal Communication).

(c) *Chemical methods of control.* These appear to offer the most rapid means of bringing the disease under control. The use of toxic chemicals brings about a rapid reduction in the snail population, and does not require the active co-operation of the indigenous population.

The qualities required in a satisfactory molluscicide have been listed as follows:[9]

(1) The chemical should be toxic in low concentrations to all stages of snails and to their eggs.
(2) It should not be dangerously toxic to man, domestic animals, crops or fish, the latter being an important source of protein in many tropical countries.

(3) It should not be easily inactivated by physical or chemical means.
(4) It should be easy to handle.
(5) It should be cheap.

About seven thousand compounds have been tested in the laboratory for their molluscicidal activity, but the number of active compounds is small. Many heavy metal compounds are toxic to snails, but the majority are either too expensive or too toxic for man or cattle. Copper sulphate was the first practical substance to be employed and has been widely used. In the Sudan an initial concentration of 30 parts per million (p.p.m.) to the main irrigation channels kills all the adult snails which breed in the smaller slow-flowing irrigation ditches. Bags filled with copper sulphate are then placed across the mouths of the smaller ditches to prevent reinfestation.

In the laboratory copper sulphate is very effective against the aquatic snail vectors of Urinary and Manson's bilharziasis. In experiments carried out at the Tropical Products Institute, 100 per cent. of adult *Australorbis* were killed by 4 p.p.m. for 24 hours while all three weeks old snails were killed by only 0·3 p.p.m. The eggs, however, are not affected by these concentrations. In a recent trial carried out in the Qalyub area of Egypt [10] a minimum exposure of 30 p.p.m. over the whole irrigation system was applied. Over a period of two years many surveys were made and fresh application of molluscicide applied whenever snails were discovered. There was a rapid fall in numbers directly after application, but at the end of a year the snails were again abundant, the numbers of one vector being unchanged. The ineffectiveness of copper sulphate against snail eggs was partly responsible for this failure but other factors were the chemical's rapid inactivation by adsorption in mud and by combination with suspended and dissolved organic matter in the water. It is also precipitated under alkaline conditions.

More recently certain phenolic compounds have been found to be very lethal to snails. Out of 701 compounds tested, Nolan *et al.*[11] found that pentachlorophenol (PCP) and its sodium salt (NaPCP) and dinitro-cyclohexylphenol (DNCHP) were the most promising. Sodium penta-chlorophenate is now being employed on an increasing scale in many parts of the world. It also kills snail eggs and has a greater residual action than copper sulphate. Although it is more expensive per pound, it is more economical in practice.

In a field trial in the Warraq El-Arab area of Egypt,[12] 10 p.p.m. was applied three times in the first year, and later when necessary. It was found that the original concentration was maintained six weeks after application. The scheme ran for five years and the prevalence of bilharzia in primary school children in the area was determined. In the years 1953-55 the prevalence of *S. haematobium* was reduced from 40 to 32 per cent. and *S. mansoni* from 5 to 3 per cent.

DNCHP has proved effective against the amphibious snail vectors of Oriental bilharziasis. It can remain on moist soil in lethal concentrations for weeks in the absence of heavy rains. McMullen *et al.*[13] found that an application in the spring and another in the autumn reduced the snail population by 99 per cent.

Physiological resistance to DNCHP has been reported recently but not so far, to a significant extent, to NaPCP.[14]

During the last two years trials have been proceeding with a new synthetic molluscicide which is effective in low concentrations. This is Bayer 73 (hydroxy-5,2-dichloro-4-nitrobenzanilide). In recent field trials carried out on a stretch of the Nairobi river by the Colonial Pesticides Research Unit at Arusha, Tanganyika, a continuous dosage of 1 p.p.m. for 12 hours was applied and completely wiped out snails and eggs for three miles downstream.[15] There was no reappearance of the vector snail five weeks after treatment. The suspension was applied by an ingenious constant flow dispenser incorporating a car windscreen wiper to work the agitator and giving a continuously variable emission rate. Such an appliance, as later modified, could be made for about £5.[16] Using this apparatus a much lower concentration could probably be used to kill the young snails if they reappear. For instance the author has found in laboratory experiments that snails two to three weeks old are all killed by 0.05 p.p.m. for 24 hours. This compound should have a promising future if it can be produced cheaply enough, as it does not cause snails to leave the water, is not affected by the presence of vegetation, and has a very low mammalian toxicity. However, at the dosage used in the field trial outlined above, it was toxic to fish, as are all the other compounds listed.

Although there is a need for better and cheaper molluscicides, much can be accomplished with the present ones if more knowledge is obtained of the most suitable methods and times of application, and particularly of snail ecology.

The Future

In recent years the public health importance of bilharzia is coming to be realized, particularly now that malaria is being controlled so successfully. The World Health Organization is taking an increasing interest in the problem and is setting up a survey team in order to assess the economic importance of the disease. However, the words of Mozley[17] are as true today as when written in 1953:

> 'Looking into the future in this field one can be reasonably sure of one thing at least, bilharzia will increase. Not only will there be more bilharzia in places where it is established already, but the disease will become evident in fresh areas.'

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Castor Beans as Food and Fodder

By W. D. Raymond

Summary

De-toxified castor beans are occasionally used as a food in Nigeria, and an industrial process for producing castor seed cake as fodder has also recently been developed. The causes of toxicity of the castor bean are reviewed and work on the de-toxification of castor is described.

The fact that, in certain parts of Nigeria, castor beans are used as food, although possibly only in times of food shortage, is surprising in view of the many reports concerning the dangerously toxic nature of castor. Furthermore, a recent report from Brazil states that castor meal is now being de-toxified industrially and will be offered in quantities of 10,000 tons or more per annum. The whole question of the de-toxification of castor beans and their use as food and fodder therefore warrants review.

The toxicity of castor bean has been recognized since the earliest times and was well known to the ancient Hebrews, Egyptians, Greeks, Romans and Chinese. The main poisonous principle present was isolated by Robert and Stillmark in 1880[1] and was given the name ricin. It is generally described as a toxalbumin and 0·18g. is usually regarded as a fatal human dose. However, it was not until 1914 that the French investigator, Alilaire[2] clearly demonstrated that two types of poisoning can be caused by the materials present in the castor bean. In addition to ricin, there is another quite different toxic principle which is an allergen. No distinctive name has been given to this principle but it is often referred to as castor bean allergen (CBA) and has been extensively investigated in the U.S.A. There is also a third, much less toxic, material present, which is the alkaloid ricinine.

Ricin has two different actions on higher animals, resembling in this way the toxins of all disease-producing organisms. The first action is a toxic effect and the second is that of an immunizer. If a sufficient dose of ricin is given by any of the usual methods of administration it will cause death and indeed there are numerous cases of human deaths on record. If, however, a smaller dose is given, only severe illness follows consisting usually of vomiting, diarrhoea, and cramp; if small but increasing doses of the toxin are administered over a period of, say, a month to six weeks, it is possible to render the subject immune to a dose more than a thousand times as great as that which would have killed it initially. In practice, to obtain immunization, a specially-treated preparation of ricin de-toxified with formaldehyde, called a toxoid and resembling diphtheria toxoid, can be used instead of the ricin itself.

The allergen (CBA) has quite different properties and has no visible toxic action the first time it is administered, even in large doses. However,

the administration of repeated small doses causes an effect which is opposite to that observed in the case of ricin. Instead of conferring greater immunity, these doses increase the animal's sensitivity to CBA. If an experimental animal has been sensitized generally, due to the administration of CBA intravenously, another dose given in the same manner may cause rapid death. Once a human being has been rendered sensitive to CBA the symptoms which are observed are quite varied, depending upon the conditions. If the skin is sensitive there may be eruptions or large weals like nettle rash; if the nose has become sensitive symptoms like those of hay-fever will occur; or if the lungs have been sensitized symptoms will resemble those of asthma. Outbreaks have been reported in the Press, such as the outbreak of bronchial asthma which occurred in South Africa affecting more than 200 persons in a factory processing castor and these are doubtless due to this effect.[3]. In fact a person who has become sensitized to CBA can detect castor in such a low concentration that the source of the irritation will be literally invisible without special aids. It is this combination of properties that leads to a double-acting toxicity in the castor bean. If the ricin alone were the toxic principle, animals would be expected to become immune by continued exposure, but the presence of the allergen cancels out the development of immunity by the development of greater sensitivity. The result is that persons working with the crushed beans become more sensitive to them with time and at no period will the beans lack the power to cause damage, since the time required to develop immunity to the one toxin is about the same as that needed to obtain sensitivity to the other.

In addition to the toxins present in the non-oleaginous substances of the bean, the oil itself is capable of acting as a purgative. The purgative effects of castor oil appear to be true characteristics of the oil and not due to the accidental presence of ricin in it. Castor oil is distinguished from most other oils by its high specific gravity, its viscosity, its solubility in alcohol and its high content of a peculiar fatty acid, ricinoleic acid. The oil content of castor seed ranges from some 35 to 55 per cent., averaging about 45 per cent., the seed containing some 70 to 80 per cent. of kernels. The seed and oil of commerce come chiefly from India, Brazil, East Africa, and the U.S.A.

World production of castor is about 400,000 tons, of which, in 1958-9, 170,000 tons came from Brazil, 110,000 tons from India and some 30,000 tons, in each case, from British East Africa and the U.S.A. Smaller amounts of castor enter world trade from many other countries and the plant grows wild in most tropical and sub-tropical areas. It is often cultivated as a peasant crop but in recent years attempts have been made in the United States to mechanize the whole production and these efforts are meeting with some success: new varieties and new methods of harvesting have been introduced there.

Owing to the high proportion of ricinoleic acid present in the oil it can be used for making other products such as monofilament nylon and lubricants for jet engines. The oil may be obtained by pressure from the seed and frequently the rather old-fashioned cage presses are used to obtain 'cold pressed' castor oil; the kind usually employed for medicinal

[*Courtesy: J. & A. Churchill Ltd.*

PLATE I. Castor Oil Plant (*Ricinus communis*)

[*facing page 20*

purposes. A further yield of oil may be obtained by hot pressing or by solvent extraction. Alternatively, the seeds may be expelled at moderately low pressures in an expeller and the residue extracted with solvent.

The composition of castor seed cake varies according to the extent to which expression or extraction of the oil has been carried out and depends upon whether the cake has been obtained from the whole seed or from the decorticated seed. The following analyses may be regarded as typical.

	Castor Seed Cake		Castor Seed Meal
	(whole seed) *per cent.*	(decorticated seed) *per cent.*	(solvent-extracted) *per cent.*
Moisture	9·8	10·4	11·8
Ash	15·0	10·5	6·0
Oil	5·2	8·8	1·1
Crude protein	20·4	46·4	30·6
Crude fibre	49·4	24·0	36·5
Carbohydrates			14·0

The fibre is mainly found in the outer shell. According to Ubbelohde (*loc. cit.* p. 140), castor seed containing 47 per cent. of oil has a content of about 15 per cent. fibre. If this seed is separated into the inner kernel and outer shell the former is found to contain 66 per cent. of oil with 0·7 per cent. fibre, whereas the shell contains a little under 1 per cent. of oil with 48·7 per cent. fibre.

At present the main outlet for castor seed cake is as a fertilizer, due to its high nitrogen content (around 6·4 per cent.), its phosphoric acid content (around 2·6 per cent.) and its content of potash (usually a little under 1 per cent.). Both field and laboratory experiments conducted in Ceylon with various organic fertilizers have shown that castor cake and meal have a high value as fertilizers and that castor seed cake is particularly effective in the cultivation of sugar cane. Castor meal has also been used by the fertilizer trade in the United States.

Regarding the potential value of the cake as fodder or food, the protein content of the decorticated cake is higher than that of many other feeding cakes (e.g. linseed about 30 per cent., rape 31 per cent., palm kernel 17 per cent., decorticated cotton about 41 per cent., copra about 21 per cent.). Regarding the amino-acid constituents of its protein, these do not appear to be abnormal when compared with other oil seed proteins such as that present in the groundnut meal, as is shown by the following figures.

	grammes per 16 g. N	
	Castor[4]	*Groundnut*[5]
Valine	6·6	4·4
Leucine	7·2	6·5
Iso-leucine	5·3	4·0
Phenylalanine	4·2	5·0
Tryptophane	0·6	1·3
Threonine	3·6	2·4
Methionine	1·5	0·9
Arginine	11·0	11·0
Histidine	2·5	2·2
Lysine	3·1	2·9
Aspartic acid	4·6	14·0
Glutamic acid	18·0	19·3

It is not therefore surprising that industrialists, faced with the difficulties in selling castor cake as a fertilizer in an increasingly competitive market would consider developing alternative uses. However, the cake left after the expression or extraction of the oil cannot be used directly as a feeding stuff because of the presence of the poisonous principles already mentioned. Various processes have been devised in the past to render the cake non-toxic such as dissolving them out with a 10 per cent. solution of salt or rendering them inert by steaming the cake or boiling it with water. Some de-toxification is obtained but whether both toxic substances are completely destroyed is not known. Although some of these attempts have been reported to be successful in making the cake non-toxic, such de-toxified cake has not found favour in the past and until recently there were apparently no commercial applications. Then, however, the Sociedade Algodoeira do Nordeste Brazileira (Sanbra), which possesses several oil factories in Brazil, developed a process for the de-toxification of castor seed.

Sanbra brand de-toxified castor is reported to be prepared by de-husking the seed and heating the meal to inactivate the ricin. It is not clear whether the CBA has also been rendered inert. Its composition, according to the firm, averages 39 per cent. protein, 19 per cent. fibre, 0·75 per cent. oil, 8 per cent. ash and 7 per cent. moisture. Often the meal contains more protein than the figure given.

The firm hopes to sell the material on the basis of its protein content considerably more cheaply than cottonseed and reports that it is possible to feed cattle with the meal over prolonged periods (up to 4 years) without ill effect, the meal sometimes forming the sole concentrate fed (unpublished report from Brazil).

Sanbra 'Lex Proteico' castor meal analysed by the Animal Nutrition Laboratory of the Zootechnical Institute at Rio de Janeiro gave the following figures:

	per cent.
Protein	38·4
Fibre	37·7
Oil	2·0
Ash	7·6
Non-nitrogenous extractive	6·5
Moisture	7·8

The fibre content of this sample seems to be exceptionally high and differs markedly from the figure given by the firm. Trials with this 'Lex Proteico' at San Paulo in October, 1958, showed that when it formed much more than 15 per cent. of the diet of poultry it caused retarded growth, and, when more than 30 per cent., increased mortality. Reports of work elsewhere state that the material was satisfactory when it formed $2\frac{1}{2}$ to 10 per cent. of the chicken feed.

Experiments have also been reported with pigs. For eight days three lots of animals received rations containing, respectively, 16 per cent. of groundnut meal, 19 per cent. of soya bean meal and 19 per cent. of 'Lex Proteico'. The gain in weight of the animals was, respectively, 103, 129, and 64 per cent. compared with that of animals on control rations, where the gain in weight was about 75 per cent. From these results it is

concluded that de-toxified castor cake is not satisfactory for the feeding of mono-gastrics, but this may be due to the high fibre content of the particular sample fed.

Exact details of the method of de-toxification employed in Brazil have not been made available but it does appear that the de-toxified cake has been used with some success for the feeding of some animals.[4]

The use of castor seed as a food occurs particularly in the Onitsha Province of Eastern Nigeria. The pre-treatment of the castor seed, designed to render it non-toxic, has been described as follows:[6]

> 'The seeds are cracked open when dry and the testa removed. The cotyledons are then wrapped in small bundles with banana leaves and boiled for an hour. They are fermented in baskets lined and covered with banana leaves for two days and then removed and pounded in a mortar to form a uniform paste. During the pounding, ashes from burnt threshed oil palm bunches are added to discourage flies. The mass is scooped out, put into leaves, tied up, dried for a day or so, and then taken to market. The finished product is called Ogili-Isi (Onitsha) or Ogili-Ugba (Awka).'

The above process is similar to the process now adopted commercially in Brazil, in that it removes the shell. However, the African also considers it important to remove the embryo of the bean before processing.

Recent American work has resulted in the elaboration of a serological method for the quantitative determination of castor bean allergen.[7] The allergen content of 10 varieties of decorticated defatted castor beans ranged from 6·1 to 9·0 per cent. This range does not offer an encouraging prospect for developing an allergen-free castor seed by plant breeding. The allergen content of five samples of commercially extracted castor seed meal ranged from 0·09 to 4·2 per cent. It appears from these figures that some allergen is lost in the commercial processing (including storage) of castor seed and this loss may at some mills amount to almost the whole of the allergen probably originally present. Brazilian meals (two samples) contained 4·1 and 4·2 per cent. allergen. U.S.A. meals (three samples) contained 0·09, 0·12 and 2·0 per cent. allergen.

Since the value of castor meal as a fertilizer is considerably less than it would command as a feeding stuff further progress in the de-toxification of castor will be followed with interest.

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Estimations of Carbon Dioxide in Stored Grain: an Indication of Condition

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SUMMARY

The temperature of stored grain is widely used as a reliable guide to its condition during storage, a rise in temperature indicating the presence of mould or insect infestation. Metabolic activity which causes the rise in temperature is also accompanied by production of carbon dioxide and it is shown that the carbon dioxide concentration is an adequate measure of this metabolic activity which can be used instead of temperature rise. By using a simple thermal conductivity gas analyzer, carbon dioxide can be measured quickly, easily and cheaply and the results indicate whether or not metabolic activity by insects or moulds is present.

VARIOUS types of grain temperature meters have been installed in most modern grain elevators. A rise in temperature (which is accompanied by an accumulation of carbon dioxide in the intergranular atmosphere[1]) indicates metabolic activity by mould or insects. Oxley[2] suggested using either the gasometric or the electric (catharometric) method for measuring excessive carbon dioxide in sealed samples of grain. The first technique has been used successfully for detecting hidden infestation in samples of grain in the United Kingdom since 1952.[3] In 1954 Milner and Geddes[4] advocated the development of a reliable method for making intergranular carbon dioxide measurements as an aid to supervising grain stored in bulk. The present work put this suggestion into effect and experiments were carried out to assess the efficiency of the method.

Measuring Carbon Dioxide

The instrument used was a gas analyzer* originally designed to measure fumigant concentrations[5] by comparing the thermal conductivity of the experimental sample with that of a sample of air not containing carbon dioxide. The apparatus was calibrated by inserting amounts of carbon dioxide into a reservoir so as to yield graded concentrations of 0-15 per cent.

Samples of intergranular air were sucked into the gas analyzer through polyethylene tubes (each 6 mm. in diameter), probing to different depths in the grain. Air samples were taken at a depth of about one metre from 87 grain bins holding wheat or, in two cases, sorghum. The concentration of carbon dioxide, the presence of insects in samples of grain drawn from

* Gow Mac Instrument Co., Madison, New Jersey, U.S.A.

the bins, the period for which the grain had been stored and its moisture content* are recorded in Table I.

Additional tests were carried out in two grain bins of an elevator equipped with electrical temperature indicators. Readings of carbon dioxide concentrations and temperatures were taken at different depths of the grain bulk. One of the bins contained local Durum wheat which was undergoing spontaneous heating (Table II); the other was filled with sound Durum wheat and was used as a control (Table III).

Carbon Dioxide Readings

The results given in Table I are grouped according to the carbon dioxide readings obtained. The largest group (48 bins) gave carbon dioxide concentrations from zero to 0·6 per cent. Of these 45 yielded grain samples which were uninfested and three yielded samples (from the bottom of the bulk) which were lightly infested. In general, where higher readings of carbon dioxide were obtained (above 0·75 per cent.), the bins gave grain samples which were found to be infested. In the case of even higher readings (above 1·35 per cent.) two factors contributing to high metabolism were involved: insect infestation and high grain moisture content, the latter probably indicating the presence of moulds. The high moisture content of the grain in some of these bins probably accounts for the fact that samples uninfested by insects were occasionally obtained from bins with high carbon dioxide concentrations.

The results summarized in Table II show a relationship between the temperatures and the carbon dioxide readings at different depths of the bins. The highest temperature readings were obtained from a level of 18 to 20 metres from the bottom of the bins whilst the greatest concentrations of carbon dioxide were found in the upper and cooler layers (at heights of 21·6 to 29 metres). Carbon dioxide concentration and temperature increased with the duration of storage. The rise in temperature of the grain was accompanied by an increase in the concentration of carbon dioxide which, after 42 days, was about 15 per cent.

Table III gives the carbon dioxide readings obtained in a bin which was judged to be commercially sound. The wheat was not sampled sufficiently to make certain that no insects were present. Nevertheless, its commercial soundness and absence of temperature rise is evidence that infestation was low. As is shown, carbon dioxide concentrations were generally very low, the highest being 0·6 per cent.

Usefulness of thermal conductivity analyzer

The results demonstrate the usefulness of the thermal conductivity analyzer for supervising grain in storage. The method proved to be a sensitive indication of deterioration of bulk grain, whether due to insects or dampness.

It is appreciated that this method cannot yield an exact measurement of carbon dioxide concentration. The readings are inaccurate due to the thermal conductivity of water vapour in the air samples. On the other hand, high water vapour concentrations in grain are usually accompanied

* Determined by a Steinlite moisture tester.

by a high carbon dioxide output. The deviation caused by oxygen depletion would hardly be noticed except in the very high readings.

The readings cannot be regarded as close measures of metabolic activity. Nevertheless, except in airtight bins a measurable concentration of carbon dioxide invariably indicates the presence of deterioration brought about by moulds or insects. The exact spot of increased metabolic activity in the grain bin cannot be located by this method. High carbon dioxide concentrations were found in the upper layers of the grain bulk at some distance from the focus of the heating zone. This is probably caused by convection currents in the intergranular atmosphere which result from temperature differentials in the bin. A similar phenomenon has been observed in soya beans by Milner and Geddes.[6] The exact location of the infestation or moulding in the grain is of minor practical importance, since excessive carbon dioxide or higher than normal temperature readings make a total examination of the bin contents necessary.

Conclusions

1. The method described provides an indication of unwanted metabolic activity in the grain bulk.
2. Fewer sampling points are needed for detecting the beginning of a dangerous condition by this means than by temperature measurement, because of the speedy diffusion of gas through the grain mass. Thermal conduction is certainly slower.
3. The thermal conductivity gas analyzer including installations for air sampling is much cheaper than a good temperature meter. It is installed more easily and would be particularly suitable for temporary storage structures.

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TABLE I

Carbon Dioxide Concentration Readings, Moisture Content, and Insect Infestation in Various Bins

No. of bins	CO_2 *per cent.*	Moisture Content Range *per cent.*	Days Stored *Range*	Insect Infestation
48	0 to 0·6	10·5 to 12·9	15–130	45 bins apparently clear. 3 bins lightly infested at the bottom.
3	0·75 to 1·2	11·8 to 12·6	10–100	All bins infested.
12	1·35 to 3·0	12·0 to 13·4	15–130	3 bins apparently clear. 9 bins infested.
10	3·15 to 9·0	12·6 to 14·1	30–200	2 bins apparently clear. 8 bins infested.
9	9·15 to 15·0	12·6 to 16·0	1–140	2 bins apparently clear. 7 bins infested.

TABLE II

CO_2 Concentration Readings and Temperature in a Grain Bin Containing Wheat Undergoing Spontaneous Heating

Height from bottom of bins *Metres*	After 6 days		After 15 days		After 30 days		After 42 days	
	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*
3·6	19	0	19	0	18	0	18	0
14·4	25	1·2	25	1·1	31	4·2	38	4·2
18	23	2·4	25	2·1	30	9·0	38	9·3
19·8*	28	—	32	—	37	—	38	—
21·6	17	5·2	18	5·1	22	14·4	26	15·0
29·0	15	5·1	16·5	6·6	15	9·3	16	13·8

Average moisture content of wheat: 12·8 per cent.
Height of bins: 30 metres.
Outside temperature during tests: 10°, 14°, 18°, 16°C. respectively.

* No gas sample taken at this point.

TABLE III

*CO_2 Concentration Readings and Temperature in a Grain Bin Containing Sound Wheat**

Height from bottom of bin *Metres*	After 6 days		After 15 days		After 26 days		After 36 days	
	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*	Temperature *°C*	CO_2 *per cent.*
1·5	16·6	0	16·6	0·15	16·6	0·15	16·6	0·30
4·0	16·6	0	16·6	0·15	16·6	0·60	17·7	0·60
6·6	16·8	0	16·8	0·15	16·9	0·45	17·7	0·45
9·1	13·0	0	14·5	0	16·8	0	17·2	0
10·4	13·0	0	13·0	0	16·8	0	17·2	0

* Average moisture content of grain: 12·3 per cent.
Height of bin: 11 metres.
Outside temperature during tests: 10°, 14°, 18°, 16°C. respectively.

The Market for Gum Arabic

By M. G. A. CHADWICK

SUMMARY

The market for gum arabic is reviewed. Statistics of production by the main exporting countries and consumption in selected importing countries are given and the main uses of gum arabic, in confectionery and some types of adhesives, are described. It is concluded that, in spite of competition from substitutes in the manufacture and processing of textiles, paints and inks, the overall demand for gum arabic will continue at about its present level in the foreseeable future.

INTRODUCTION

THERE is a well established market for gum arabic in several countries. World trade amounts to some 50,000 tons or more annually. In the United Kingdom, the largest single market, imports now total 11,000 to 13,000 tons annually and are valued at £1·3 million to £1·6 million.

The demand for gum arabic is principally for a carefully graded and cleaned high-quality product suitable for use in foodstuffs and certain adhesives. Usage has declined in some particular instances, owing to competition from substitutes, but in spite of increased production in recent years, demand generally has remained firm and prices have shown no tendency to weaken. By far the largest quantity of gum arabic is used in confectionery, where consumption has not been affected by substitutes and is expected to persist at its present level. New producers, however, may normally expect to find a continuing market only if their gum is of high and consistent quality and is regularly available.

PRODUCTION AND QUALITY

Gum arabic is a water-soluble type gum obtained from a limited number of the many species of *Acacia*. *Acacia senegal* (syn. A. Verek) provides the highest grades of gum arabic and is the source of the greater part of the world's supplies of this gum. *A. seyal* is also much exploited, but provides a gum of lower quality, whilst a number of other species of *Acacia* are exploited to a limited extent. For instance, a gum is derived from *A. drepanolobium*, which constitutes the chief source of Tanganyika gum arabic, although the gum produced is of a different character and of a less general application than that of *A. senegal* or *A. seyal*. Lower quality

gums should on no account be mixed with *A. senegal*. The gum must also be graded to consistent standards of cleanliness and purity. It should be free from all foreign matter, such as twigs, bark, fibre and sand, and it is particularly important that it should be completely soluble in water. Finally, although clean dark gum of consistent quality might find a market, the paler grades are much preferred, so the gum should be either colourless or of the lightest possible colour.

Where gum arabic is available in commercial quantities, but cannot be cleaned and graded to the highest standards which would make it acceptable to the markets of Western Europe or the United States, the Indian market may provide some outlet. Unsorted gums, and gums of a quality not normally acceptable in these markets, are already imported into Bombay to be sorted for local consumption or for re-export.

There is no apparent shortage of gum arabic at present. World production has increased from its pre-war level of about 30,000 to 35,000 tons per annum to reach 50,000 tons or more annually in recent years. Actual production statistics are not readily available but, since little of the gum is consumed in producing countries, export statistics generally provide a fairly reliable guide to production. Table I shows annual exports of the four major gum-producing countries, 1951 to 1959.

TABLE I

Exports of gum arabic from major producing countries
(*tons*)

	1951	1952	1953	1954	1955	1956	1957	1958	1959
Sudan . .	41,044	32,015	39,979	38,524	41,877	49,226	43,254	48,069	42,328
Fr. W. Africa	3,159	5,583	4,477	5,488	5,385	5,551	5,617	5,544	4,961
Nigeria . .	1,601	2,515	1,830	728	1,709	1,132	785	1,851	2,524
Tanganyika .	1,689	564	1,346	1,534	2,125	1,542	683	503	*a*

Sources: Sudan Annual Foreign Trade Report; Bulletin Mensuel de Statistique d'Outre Mer; Nigeria Trade Summary; Annual Trade Report of Kenya, Uganda and Tanganyika.
a Not available.

(a) *Sudan*

As Table I shows the Sudan is by far the largest single producer of this commodity. Among the reasons for the success of the long-established Sudan gum arabic industry are the existence of large, pure stands of *A. senegal*, the availability of skilled cheap native labour for tapping and collecting supplies, and the reliability of its grading standards and of the various marketing arrangements. The gum is sold by native pickers under a system of government regulated public auctions introduced in 1922, and is then graded and prepared by the large exporting firms before shipment overseas.

The largest part of the Sudanese output consists of gum 'hashab', the gum derived from *A. senegal* and generally described as 'Kordofan' after the province in which the gum industry is largely centred. Kordofan gum has come to imply a virtual guarantee of quality and constitutes the

standard by which any other production would be judged. Gum from *A. seyal* is separately marketed as gum 'talha'. Only relatively small quantities of this gum are traded.

(b) *French West Africa*

The second largest production of gum arabic takes place in the former French West African colonies, chiefly in the Republic of Senegal. The gum is produced from *A. senegal* and is classed by three main qualities before shipment to France, where it is further graded on arrival at Bordeaux.

(c) *Nigeria*

Nigeria is a small producer of gum arabic. The industry is relatively well organized, however, for tapping is now practised and the gum is graded before export. Although gum is also shipped to Europe and the United States, a major part of the Nigerian crop is taken by the United Kingdom.

Three main classes of gum are recognized. 'Falli' are the high-grade white or paler gums, and include 'Kolkol' gum produced from *A. senegal*, comparable with the gum 'hashab' or 'Kordofan' of the Sudan. The yellow or red-tinted 'Marrua' gums, derived from *A. seyal* or *A. xanthophloea*, comprise the second class and are comparable with the gum 'talha' of the Sudan. The third class consists of *Combretum*.

(d) *Tanganyika*

The bulk of Tanganyika's gum arabic is obtained from *A. drepanolobium* and is generally characterized by a lower viscosity than that derived from *A. senegal* or *A. seyal*. Smaller quantities are derived from *A. senegal* and from several other species of *Acacia*. Tapping is not practised in Tanganyika and the gum is not graded. It is not, therefore, marketed in Europe or America, but is shipped chiefly to Bombay and may be re-exported as East Indian gum arabic.

Production in Tanganyika shows considerable fluctuations from year to year. This is said to occur because the gum is collected chiefly when other crops fail or show poor returns. At other times there is less incentive to undertake the relatively arduous task of gum collection.

(e) *Other countries*

In India there are several indigenous species of *Acacia* from which gums are derived, one of the commonest being *A. arabica*. Gum is also collected from *A. catechu*, *A. modesta*, *A. farnesiana* and various other species, including *A. senegal*. The latter species is restricted in its distribution and only limited quantities of its gum are available. Gum from all these species of *Acacia* is rarely available in the pure state, but is commonly mixed with other gums. Furthermore, Indian gum arabic is mostly consumed locally in edible products and does not enter into world trade to any significant extent.

Small quantities of gum arabic have been produced in other countries but are of little commercial importance. Italy has taken a little gum

from Somaliland and, before the last war, small amounts of gum arabic were imported into the United Kingdom from Kenya. This gum was not cleaned or graded and would not always produce true dispersions in water and, as a result, the trade in this product became virtually extinct.

The development of the gum arabic industry in Senegal, Nigeria, Tanganyika and other countries has been severely handicapped by the absence of pure stands of *A. senegal* and by the lack of any carefully regulated marketing system such as that established in the Sudan. The existence of mixed stands has led to variations in the local product which can be corrected only by teaching the native collectors to distinguish the right trees for tapping and collection. Some progress has been made in this direction but not enough to compensate for the absence of pure stands.

Grading and Packing

Gum arabic must be regularly available in suitable qualities which are uniformly graded. Since gum arabic varies considerably in its character according to the species, age and condition of the tree, and season and weather at the time of picking, adequate grading is of prime importance. When this consideration has been neglected, as in the marketing of Kenya gum arabic before the war, the product has acquired a bad reputation and has failed to find a continuing market.

Colour, cleanliness, and size of fragments together with viscosity of solution and flavour, are the usual criteria of value in grading Sudan gum. The five main commercial grades of Sudan gum: natural, cleaned, cleaned and sifted, hand-picked selected, and bleached, are described in Appendix A.

Gum arabic is normally packed in double jute bags of about 220 lb. each. The outer bag should be new and unused, but the inner bag, if in good condition, need not be new.

Merchant firms and some consumers are careful to distinguish 'old crop' gum from 'new crop'. Gum arabic grows harder during storage and certain consumers prefer to use only the relatively hard and brittle 'old crop' which is easier to pulverize before use and shows less tendency to jellify in solution.

Imports of Gum Arabic into the United Kingdom

The United Kingdom is the largest single importer of gum arabic, imports having increased from some 6,000 tons annually before World War II, to between 11,000 and 13,000 tons annually in recent years—between one-quarter and one-fifth of world output.

The greater part of these imports comes from the Sudan, but imports from Nigeria are also important. The latter fluctuate considerably from year to year, but may account for anything from one-eighth to one-quarter of the total. Imports of gum arabic into the United Kingdom, 1955 to 1959, are shown in Table II.

The figures from United Kingdom Trade Returns imply that exports of gum arabic from Nigeria may be somewhat larger than are indicated by the statistics of Nigerian exports shown in Table I.

TABLE II

Imports of gum arabic into the United Kingdom
(tons)

	1955	1956	1957	1958	1959
Imports from:					
Sudan	8,328	10,976	9,562	9,726	8,951
Nigeria	2,486	1,795	1,815	1,371	3,329
Other Countries	41	52	21	69	234
TOTAL IMPORTS	10,855	12,823	11,398	11,166	12,514
RE-EXPORTS	737	1,013	902	761	*a*
NET IMPORTS	10,118	11,810	10,496	10,405	*a*

Source: Annual Statement of the Trade of the United Kingdom.
a Not available.

IMPORTS INTO OTHER COUNTRIES

The major consumers of gum arabic are the United States of America, Japan, Mainland China, Australia, India and various continental European countries, in particular, France, Italy, the Netherlands, Belgium, West Germany, Denmark and Sweden. With the exception of France, which imports the bulk of the former French West Africa territories' produce, and India, which imports most of the output of Tanganyika, all derive their supplies almost entirely from the Sudan.

The export destinations of the Sudan's exports of gum 'hashab', 1957 to 1959, are shown in Table III.

TABLE III

Export destinations of gum 'hashab' from the Sudan, 1957-59

	Export destination	Average quantity taken (*tons*)	Percentage
1	United Kingdom	9,011·0	23·0
2	United States	8,776·3	22·4
3	Italy	3,721·3	9·5
4	Netherlands	2,573·3	6·5
5	France	1,880·7	4·8
6	Belgium	1,657·7	4·2
7	Japan	1,573·3	4·0
8	West Germany	1,553·3	4·0
9	China	1,198·7	3·1
10	Australia	1,026·0	2·6
11	Denmark	790·3	2·0
12	Sweden	698·7	1·8
13	India	631·3	1·6
14	Other Countries	4,105·0	10·5
	TOTAL EXPORTED	39,197	100·0

Source: Based on Sudan Annual Foreign Trade Reports.

Uses of Gum Arabic

The main uses of gum arabic are in foodstuffs and adhesives. The gum once also had a considerable use in textile manufacturing processes, but this use is declining and appears to be of relatively minor importance in most countries. A number of other industries is known to use gum arabic in small quantities.

(a) *Foodstuffs*

Being odourless, colourless, tasteless, non-toxic and soluble in water, gum arabic is used to impart desirable qualities to the body, texture, and viscosity of various foodstuffs. Its main use is in confectionery, principally in fruit gums, cough drops and pastilles, but it also finds a limited use in flavour emulsions used in soft drinks, in dairy products and in sauces. In the U.K. the foodstuffs industry is estimated to account for between 50 per cent. and 70 per cent. of gum arabic consumed, use in confectionery accounting for the bulk of this. In the United States it is estimated that about 55 per cent. of imports are consumed in foodstuffs. It has been estimated that about three-quarters of the production of gum arabic in the Sudan finds its way into the world confectionery trade.

(b) *Adhesives*

The second largest use of gum arabic is in adhesives, in gums of the re-moistenable type, including gummed tapes, labels, envelopes and postage stamps, and in adhesive mucilages for office and domestic use. Gums derived from gum arabic have the advantage of being easy to prepare, light in colour, odourless and stable. Consumption of gum arabic in adhesives is estimated to account for between 15 per cent. and 20 per cent. of imports into the United Kingdom.

(c) *Textiles*

Gum arabic may be used both in sizing and finishing textiles such as silk and rayon, and in calico printing. In these uses gum arabic has suffered from the competition of substitutes, such as potato starch, and usage is now relatively small. It is the lower quality grades of gum arabic which are used mainly in textiles manufacture and imports into the United Kingdom of the inferior quality Sudan gum 'talha' have declined appreciably over the last two decades. Since India now takes the greater part of the Sudan's gum 'talha' and also most of the Tanganyika output, consumption of gum arabic by the textile industry in India may remain of some significance.

(d) *Pharmaceuticals*

Gum arabic was once used extensively in pharmaceuticals but consumption has declined with the advent of cheaper and more satisfactory products. Its use is now largely confined to suspensions for carrying medicaments and there is also some small usage in emulsions and as a binding agent in tableting, principally in those instances where a harder,

slow-dissolving tablet is required. Appendix B shows pharmacopoeia requirements in the United Kingdom and the United States.

(e) *Other industries*

Other industries which use gum arabic include ironfounding (in core compounds), fireworks manufacture, lithography, high-quality artists' colours, matches, speciality inks, crayons, high-quality paper manufacture and speciality paints. Usage in most of these instances is believed to be relatively limited, although it is possible that there may be some larger undisclosed consumption in processes of a confidential nature.

Substitutes

The use of gum arabic in foodstuffs, particularly in confectionery, is not at present threatened by substitutes. Gelatine and other products may replace gum arabic in some instances, but generally the use of gum arabic in confectionery of the harder 'chewy' type of gums is expected to continue at about its present level.

In adhesives there are readily available substitutes such as starch dextrines, for use in both re-moistenable glues and in general office and domestic mucilages. In the former use, however, gum arabic is preferred both because it gives greater flavour acceptability to gummed products, such as gummed tape, labels, envelope flaps and postage stamps, and because it is less likely to become sticky during storage. The use of gum arabic in both types of adhesive is, in the United Kingdom at least, largely accounted for by a very few manufacturers. These show no sign of making any major change to substitutes at present, but it should be appreciated that possible alternatives exist and that these could be used at some future date.

In other uses, which are mostly in technical rather than edible products, 'synthetic' substitutes such as polyvinyl alcohol have already been used to replace gum arabic to a certain extent, having the important advantages of stable prices, uniformity and consistency and well-defined grades of quality. In some instances, however, gum arabic is still preferred because it is considered that there is not yet available a really successful substitute at a comparable price, or because manufacturers are reluctant to depart from the use of established methods and materials as long as regular supplies of reasonably priced material are available.

Prices

Prices of gum arabic often remain steady for long periods, but may at times be subject to wide fluctuations. Since the world market is heavily dependent upon supplies from the Sudan, a series of short crops in that country can lead to shortages and high prices. The grade most commonly traded is the high-quality standard grade 'cleaned Kordofan', for which prices, 1955 to 1959, are shown in Table IV for both the United Kingdom and the United States.

TABLE IV

Gum arabic prices in the United Kingdom and the United States

	1955		1956		1957		1958		1959	
	Low	High	Low	High	Low	High	Low	High	Low	High
U.K., shillings per cwt. c.i.f.	123	147·5	128	150	127	147·5	122	130	121	192
U.S., dollars per lb.	0.20	0.22	0.21	0.23	0.21	0.21	0.21	0.21	0.21	0.295

Sources: *Public Ledger*, London, and *Oil Paint and Drug Reporter*, New York.

Although higher prices are recorded, prices for this 'standard' grade have normally ranged in the United Kingdom from about 120*s*. to 140*s*. a cwt. Outside the producing season, which extends from October/November to May/June, prices may rise above this level in those years when stocks in merchants' hands are low following a short crop. It seems to be accepted in the trade that prices may range at the extremes from about 115*s*. to 180*s*. or 190*s*. a cwt.

In 1959, following a short crop in the Sudan, prices rose considerably both in the United Kingdom and the United States. In the United Kingdom they rose from their previous 'normal' level of 120*s*. to 140*s*. a cwt. which had persisted for some years, to about 160*s*. to 180*s*. a cwt. It has been suggested that in future 'normal' prices may possibly continue at this level, fluctuating around 150*s*. to 160*s*. a cwt.

Other grades traded in the United Kingdom to a smaller extent range at present from about 60*s*. a cwt. for the lowest-quality material known as 'dust' to about 330*s*. a cwt. for the very highest-quality 'bleached' grade.

APPENDIX A

MAIN COMMERCIAL GRADES OF SUDAN GUM 'HASHAB' OR 'KORDOFAN' GUM

1. *Natural*

This grade consists of gum in its original condition as picked from the tree. Pickers are expected to exercise care in removing the gum from the trees and a premium may be paid for 'natural' gum which is in a clean condition. This grade is not normally exported, since in most instances hand-sorting would be required and the cheap skilled labour which is necessary for this operation is not available in importing countries.

2. *Cleaned*

Gum arabic is most commonly traded as 'cleaned'. Impurities such as bark and twigs, and pieces of other types of gum, are removed by hand-sorting, together with some of the smallest fragments and gum 'dust'.

Pieces of bark firmly embedded in the 'tears' of gum are removed by breaking the gum with stones.

3. *Cleaned and Sifted*

The gum is collected, stored and cleaned in sandy desert country, so an admixture of sand is commonly present. Some of this sand, and the gum 'dust', is removed by sieving through a 20-30 mesh sieve, after which the gum is packed in bags to avoid further contamination.

4. *Hand-picked selected*

Small quantities of gum are specially selected by hand-picking to consist only of larger pieces of a specified size and colour.

5. *Bleached*

There is a small demand for a gum which is practically white or colourless. This is satisfied by a few local merchants who bleach specially selected gum by exposure to the sun in the hottest season for a period of at least two months or more, during which time it is constantly turned and examined. The process reduces the moisture content, imparting a uniform light colour and frosted appearance.

Attempts to use machinery for sorting gum arabic, in place of skilled manual labour, have generally proved unsuccessful. It is believed that a few sorting machines are in use, but these are employed in a limited field, grading by colour only where large quantities of the smallest pieces are traded.

APPENDIX B

Pharmacopoeia Requirements

1. *United Kingdom*

Gum arabic (gum acacia) should possess the following characteristics:

(a) it should be insoluble in alcohol;
(b) it should be almost entirely soluble in an equal weight of water yielding a translucent, viscous, slightly acid solution which is not glairy and, when diluted with more water and allowed to stand, does not yield a gummy deposit;
(c) it should not contain more than 0·5 per cent. insoluble matter;
(d) it should not contain more than 0·5 per cent. acid-insoluble ash;
(e) it should not contain more than 5·0 per cent. total ash.

2. *United States*

Gum arabic (gum acacia) should possess the following characteristics:

(a) it should be insoluble in alcohol;
(b) one g. of gum arabic should dissolve in 2 ml. of water;
(c) it should not contain more than 0·5 per cent. acid-insoluble ash;
(d) it should not contain more than 4·0 per cent. total ash.

Notes

Oil from Nutmeg Leaves.—The possibility of using oil extracted from nutmeg leaves as a substitute for nutmeg oil when nutmegs are scarce has sometimes been considered. A recent examination at the Institute suggests, however, that nutmeg leaves are unlikely to be of value for this purpose.

Two samples of nutmeg leaves, green and brown in colour respectively, were sent to the T.P.I. by the Grenada Co-operative Nutmeg Association for analysis and trade evaluation.

Both samples of leaves were steam-distilled and the yield of oil calculated on the weight of the leaves as received was 0·65 per cent. for the green leaves and 0·34 per cent. for the brown leaves.

The oils obtained from both green and brown leaves were mobile and of a pale yellow colour. The odour of the oil from the green leaves examined on a paper strip, resembled that of normal West Indian nutmeg oil, but was musty and less sweet. On evaporation the musty note persisted for a long time and the final odour of the oil lacked character. Oil obtained from the dry leaves had an odour reminiscent of clary sage rather than nutmeg, but the resemblance to true West Indian nutmeg increased on evaporation. The brown leaf oil was stronger and more pleasant than the green leaf oil throughout. An analytical examination of both oils was made and the results compared with the British Pharmacopoeia (1953) Specification for West Indian nutmeg oil. Only by small differences in alcohol solubility and optical rotation did the two oils not conform with the specification.

The gas chromatography traces of both leaf oils showed that they were broadly comparable with genuine West Indian nutmeg oil in composition, although there were small differences in the proportions of the constituents.

Small samples of the oil were sent to a firm of essential oil merchants and two firms of essential oil distillers. Their reports agreed that the oils were very poor as regards flavour and in this respect they could only be used in small quantities as adulterants. One firm suggested that the oils could possibly be used for perfumery purposes but were unlikely to be of much value.

From these reports it is clear that, in spite of the close chemical resemblance of these oils to true nutmeg oil, the differences, although small analytically, are such as to render the oils of little value for flavouring purposes.

G.B.P.

Book Reviews

REPORT OF THE SEVENTH COMMONWEALTH ENTOMOLOGICAL CONFERENCE, 1960, 399 pp., 10 × 6¾. (London Commonwealth Institute of Entomology). Price 50*s*.

The Commonwealth Entomological Conference was held from the 6th to the 15th July, 1960, and the editor of this report is to be congratulated on producing this volume so quickly. Representatives from 22 territories attended, as well as from the Colonial Office and the Food and Agricultural Organization. The Conference was under the chairmanship of Mr. A. Perera, chairman of the Executive Council of the Commonwealth Agricultural Bureaux.

The volume starts with three appendices summarizing the work since the last Conference (1954) of the Commonwealth Institute of Entomology and the Commonwealth Institute of Biological Control, and the proceedings of the committees.

The work of the Conference falls into three natural categories, that is:

(i) Control of pests by means of insecticides;
(ii) Biological control;
(iii) Viruses and their vectors;

though naturally a number of important miscellaneous subjects were also dealt with, such as studies of insect dispersion, timber boring pests, termites in afforestation projects, and locust control.

Dr. J. T. Martin's paper contains a useful summary of the new insecticides available, together with a valuable table of the new organo-phosphorous products: there is also a list of the new chlorinated compounds together with some miscellaneous compounds such as the carbamates Servin, Vapam, Dimetilan and Tridipam. A fluoacetamide and a compound of the 'phenol-ester' type are new departures in insecticides. This paper was followed by one from Dr. A. B. Hadaway who dealt with problems in the use of insecticides: for instance at times no benefit resulted from spraying, an example being coconuts in East Africa where better *Pseudotheraptus* control was obtained from clean cultivation than from the use of insecticides.

Dr. Hadaway points out the importance of co-operation among the apparent disciplines in order to achieve good results, particularly in ecology, droplet size, formulation, rate of application and biological effectiveness.

The hazards of using pesticides were dealt with by Dr. J. M. Barnes and Dr. E. J. Miller and there is a short and interesting table of comparative danger of pesticides and causes of accidents from them. A serious deficiency in English law was pointed out, namely that there is no specific protection, in the sense of a legal tolerance of pesticide in food in this country, except for one substance—arsenic, a fact which, in the reviewer's opinion, puts us far behind many other nations in this respect.

An important section is that devoted to biological control, which was introduced by Mr. Frank Wilson, who pointed out that the subject is now becoming fashionable again largely because of the new interest in population dynamics and the disillusionment following the great expectations raised by the development of chemical control. There is a section by Dr. K. M. Smith on the use of pathogens in biological control and the late Dr. L. L. J. Ossowski contributes an important account of the use of virus to control wattle bagworm in Natal.

Locusts, timber pests, termites, tsetse fly and plant virus vectors are all dealt with and the volume ends with a number of regional summaries of work being done in the various Commonwealth territories. There is no index, but that would hardly be possible in this admirably presented report, appearing so soon after the event.

G.O.

SYNECOLOGY AND SILVICULTURE IN GHANA, by Charles J. Taylor. 418 pp., 120 plates, numerous line drawings, maps, 9⅜×6¾. (University College of Ghana and Thomas Nelson & Sons Ltd., Edinburgh, 1960.) Price £5.

Dr. C. J. Taylor has done a great service to tropical forestry in general and to Ghana in particular by producing this admirable work on the ecology of Ghanian forests. It provides much more than the broad classification of the natural vegetation that the author felt was required and is a model of what such a work should be, summarizing as it does the long experience of an expert.

The short first part of the book contains some good summaries: to introduce the subject, for instance, there are accounts of the history of the country, its topography, climate, soils and life forms, though this last refers to plants only. Part II deals with vegetation and Part III with silviculture.

In his study of vegetation Dr. Taylor uses the Tansley 'dynamic' system of classification, that is the concept that natural vegetation is constantly changing and the 'climax' is thus only a position of relative stability, reached after a series of trends have been at work. This leads to a position which may endure for either a long or a short period. The author points out the great mistake of treating the words 'climate' and 'climax' as though they were almost synonyms and emphasizes that they even come from different Greek roots, which is a most salutary reminder.

The different vegetation habitats are then dealt with, such as the High Forest, Savannah-Woodlands, Coastal Scrub and Grassland and Marine; among this is a very interesting chapter on seral communities in the High Forest zone, describing disturbances introduced by man—hunting, wars, food farms, cocoa cultivation, timber extraction, mining and so on. It is interesting to note the author's conclusion that timber exploitation of a very selective nature in the past, that is the extraction of the larger girth 'mahoganies', has caused very little harm to the natural forest.

The accounts of the different Savannah-Woodlands are also of exceptional interest with their descriptions of the dominant part played by fire in forming the present climax vegetation; the author considers that this zone has encroached on the High Forest zone.

Part III of the book is by far the largest and is devoted to silviculture. Dr. Taylor points out that he has had to limit his account, and has selected about 160 trees for description, but that those chosen are either merchantable timber at the moment or are trees which are of ecological importance. In a particularly happy phrase he defends his choice, saying, '. . . the choice is that of a forester, who feels that these are the trees of the High Forest which comprise his principal working tools.'

The trees are described by families. The scientific name is given, then follow the English and vernacular names in several languages, a description of the tree, the botany, an account of the seedling, the distribution, regeneration, both artificial and natural and field notes. Special notes are made in some cases, such as on the preparation of bark cloth from *Antiaris africana*.

The practical forester shows through in many cases, for instance the insistence on the importance of seedling identification and the warning against picking up leaves from the ground in order to identify a tree; the slash is, says Dr. Taylor, a far better method of establishing the species, apart from climbing into the crown and examining that. Again, Dr. Taylor points out various other dangers. For instance, vernacular names may vary from place to place, and growth rings are not necessarily annual rings and thus may not be a guide to a tree's age.

The book is illustrated with good plates of trees and line drawings of leaves, fruit, seedlings or flowers and there are two maps in a pocket. There are seven important appendices, a phenological table of the tree species, seed and germination data and detailed enumeration surveys of six areas.

With becoming modesty the author describes the book as forming a basis from which specialists may work in the future: if they do it is to be hoped that they can maintain as high a standard as Dr. Taylor.

G.O.

BEE KEEPING IN THE TROPICS. By Francis G. Smith. xvii+265 pp., 69 plates, numerous line drawings, 8½×5½. (London: Longmans, Green & Co. Ltd.) Price 45*s*.

This volume, written by the Head of the Bee-keeping Division of the Forest Department, Tanganyika, is one of a series of books on tropical agriculture being published by Longmans, Green & Co. Ltd. Its aim is to provide all those interested in bee keeping in the tropics with a handy reference and guide book, with particular emphasis on the practical aspects.

The potentialities of the production of honey and beeswax in the tropics are very great but, apart from some developments mainly in America, little has been done except to gather wax from wild swarms of bees.

The first part of this book concerns basic principles of the biology, behaviour, diseases, enemies and nutritional requirements of the honey bee. The economics of bee-keeping methods are not neglected. This section is followed by one devoted to types of equipment available. Various types of hive, hive tools, veils, gloves and the like are fully described.

The third part of the work is concerned with bee management. The method of handling simple as well as more modern hives is amply described. Special emphasis has been laid on the importance of bee breeding, something any bee keeper can and should tackle if he is to obtain maximum production.

Lastly a section is devoted to the crop itself—honey and beeswax. The methods of cleaning honey from primitive hives and various types of presses are fully dealt with. Included in this section are extracts from the Tanganyika Produce Export Ordinance, together with notes on how to develop a bee keeping industry.

In the appendices can be found lists of recommended text-books, with a brief description of their contents, suggested periodicals of special value to bee keepers, lists of Bee Keepers' Associations, and conversion tables dealing with the relationship between specific gravity, refractive index and the moisture content of honey.

The whole work is excellently arranged, well illustrated, and should be added to any library that is concerned with bee keeping in the tropics.

W.D.R.

ANIMAL HUSBANDRY IN THE TROPICS. By G. Williamson and W. J. A. Payne. 435 pp., 9 × 5½. (London: Longmans, Green and Co. Ltd., 1959.) Price 48*s*.

This volume, one of a series of books on tropical agriculture, has the ambitious aim of summarizing for students and junior technical officers all the basic knowledge concerning the production and development of the economically important domesticated animals in the tropics.

The work is divided into three main parts. Part I deals with basic principles—climate, health and nutrition. Part II describes methods of husbandry which have been successfully applied to each species. Part III deals with milk and meat products.

Some idea of the scope of the book may be gained from the following random selection of chapter headings: 'The Effect of Climate on the Animal', 'Parasitism', 'Nutrition', 'Breeding', 'Cattle', 'Sheep', 'Goats', 'Camels', 'Pigs', 'Poultry', 'Milk and Milk Products', 'The Preparation of Meat and Carcase By-Products'.

In the preface to the book, the authors make the interesting point that, though most of the practices of illiterate tropical peoples in managing their livestock may appear to the newcomer to be fundamentally unsound, an extended acquaintance generally brings home the fact that the greater part of their practice is nicely tuned to the conditions under which they live. Attempts at radical change without first changing the basic economy may well be disastrous. In the past, attempts to reform methods of animal husbandry and to develop livestock in the tropics have been based on knowledge inapplicable to tropical conditions and it is only comparatively recently that research on the essential basic facts of life affecting animals in the tropics has been seriously undertaken. The authors have taken into account the results of this research in making their comments and recommendations.

The book is well written in simple, direct English and there are numerous excellent illustrations, both in colour and black and white. The authors have had the assistance of a number of experts who have written on the subjects in which they have specialized and whose authorship is acknowledged in the text. The volume can be thoroughly recommended to all those concerned with livestock production in tropical areas.

M.K.

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Compiled by Miss V. Clarke

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